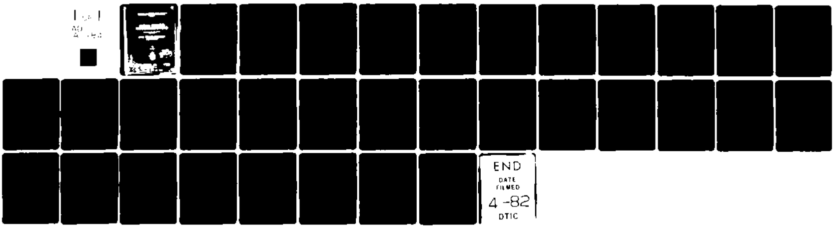
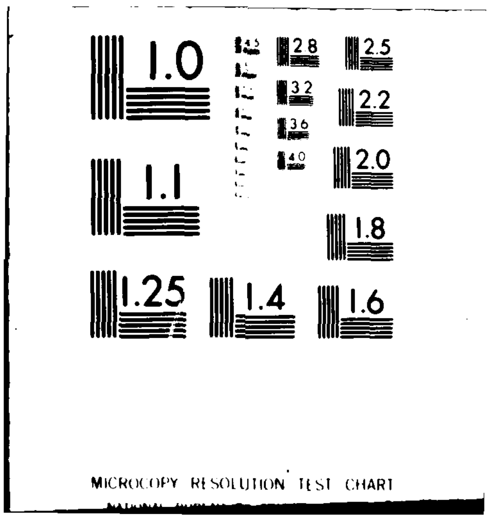
AD-A111 841 DEFENCE RESEARCH ESTABLISHMENT OTTAWA (ONTARIO) F/G 17/4
HF/VHF SPECTRUM SURVEILLANCE ESM RECEIVER.(U)
SEP 81 R LUIZ
UNCLASSIFIED DREO-TN-81-17 NL




1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

3

RESEARCH AND DEVELOPMENT BRANCH

DEPARTMENT OF NATIONAL DEFENCE
CANADA

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

TECHNICAL NOTE NO. 81-17

HF/VHF SPECTRUM SURVEILLANCE ESM RECEIVER

by

R. _uiz

Electronic Warfare Division

COMM EW Section

PROJECT NO.
31E10

SEPTEMBER 1981
OTTAWA

ABSTRACT

This report provides the design criteria, functions, capabilites and drawbacks of a HF/VHF spectrum surveillance ESM Receiver. It is designed to perform scanning of an operator-selected frequency band and perform signal identification upon detecting a signal. More emphasis is given, in this report, to the signal identification procedure which is one of the novel innovations incorporated into the receiver. The ESM Receiver is capable of identifying CW, AM, FM, SSB, DSB and PSK signals.

RÉSUMÉ

Ce rapport décrit les critères de conception, les capacités fonctionnelles et les défauts d'un système de surveillance du spectre électromagrétique (bandes HF/VHF). Le récepteur est conçu de façon à pouvoir balayer une bande de fréquence choisie par l'opérateur et de faire de l'identification du signal. L'emphase est mise dans ce rapport, à la procédure d'identification du signal, qui est une des nouvelles innovations incorporées dans le récepteur. Le récepteur peut identifier des signaux du type OE, MPA, MPF, BLU, BLD, MDP.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

The HF/VHF spectrum surveillance ESM receiver developed by Miller Communications Systems under a DND Contract is a multiband, multifunction electronic equipment designed to facilitate the interception and identification of unknown signals or transmissions. The ESM receiver is fabricated to be an experimental device initially to be used in evaluating the following aspects of the receiver design:

a) Automatic spectrum surveillance
b) Signal identification technique
c) The application of microprocessors
d) Information and graphic display
e) Performance in realistic environment
f) User features.

The ESM receiver is developed to function in a tactical military environment as an intercept receiver. The spectrum coverage of the receiver is defined as HF/VHF or specifically 1 - 300 MHz. It is capable of scanning a prescribed portion of the above spectrum, detecting the presence of voice modulated signals, demodulating and identifying the modulation type of the signal. Modulation formats of primary interest are: AM, FM, DSB, SSB, CW and PSK.

Major areas of technical innovation are:

a) Microprocessor control of receiver functions
b) Software-aided signal identification
c) Semi-automated manual mode operation
d) Multi-mode demodulator technique
e) Signal identification strategies
f) Voltage-controlled filter techniques
g) Alphanumeric and graphic display.

2.0 RECEIVER STRUCTURE

The basic structure of the receiver is shown in Fig. 1.

As is evident from Fig. 1, the ESM receiver is a triple conversion superheterodyne system converting the RF input to a final 455 KHz at which the demodulation takes place. An optional 10 dB fixed attenuation may be electronically switched in if strong RF signals are encountered.

2.1 Voltage Tuned Filter (VTF)

The purpose of the Voltage Tuned Filter (VTF) is to reduce the distortion from undesired interference. The band 20 MHz to 140 MHz has been selected for implementation of the VTF. By narrowing the bandwidth of reception adjacent to a desired frequency the receiver front end circuit essentially can realize reduced distortion from undesired signals.

The tuning of VTF is realized by selecting different combinations of inductors and capacitors. A total number of 47 filter combinations, bandwidth ranging from 11 MHz to 0.1 MHz, in a more or less decreasing order from higher frequency to lower frequency of the band, are implemented in the VTF. To minimize distortion effects PIN diode switches are used for switching these filter combinations.

The capacitor/inductor combination for a particular bandwidth resides in a filter look-up table in the memory. As the receiver is swept through a selected frequency range, or if the operator manually selects a frequency range, the appropriate logic levels are sent from the microprocessor to the VTF preselector module via a PIA. A digital interface board in the preselector module decodes the control word from the EXORcisor and drives appropriate switches as well as providing a local status display on the front panel of the receiver.

If the band selected falls outside of 20 MHz to 140 MHz range, ie 1 MHz - 19 MHz and 141 MHz to 300 MHz ranges, the microprocessor sends commands to bypass the VTF and the status will be likewise indicated on the front panel of the receiver.

2.2 Frequency Conversion and Bandwidths

Following the VTF there are four image reject filters with overlapping passbands. These bands and associated local oscillator and IF frequencies are shown in Table 1.

TABLE 1

RECEIVER IF AND LO FREQUENCIES

BAND	FREQ. RANGE MHz	1^{st} LO/IF MHz	2^{nd} LO/IF MHz	3^{rd} LO/IF MHz
A	1-30	123-152/122	132.7/10.7	
B	30-90	152-212/122	132.7/10.7	10.245/0.455
C	90-195	160-265/70	80.7/10.7	
D	195-300	317-422/122	132.7/10.7	

Signals within the band selected are amplified and converted to the first IF frequency, which is switchable between 122 MHz and 70 MHz, by mixing with the synthesized local oscillator signal. Though the basic step size of the frequency synthesizer (Rockland 5600) is 1 Hz, it can be programmed to provide LO signals with increments of 4 Hz since for band D the synthesizer signal will be frequency multiplied by 4.

Since the synthesizer operates only up to 160 MHz, a form of frequency multiplication using a single passive doubler is employed as a doubler as well as a quadrupler. For band A, B and C the required output of the doubler is the second harmonic of the input synthesizer frequency. For band D operation use is made of the fourth harmonic of the input synthesizer frequency. Sufficient amplification is provided to bring the final output of the multiplier circuit to >+17 dBm. Switching control for the multiplier module is from the logic driver section in the RF module which is in turn driven from the digital tuner (see Sec. 2.4.1 for the digital tuner operation).

The receiver has two more frequency conversion and amplification stages to get to the final IF frequency of 455 KHz. Fixed frequency VECTRON crystal oscillators are used for the second and third frequency conversion.

At 455 KHz, digitally controlled analog switches select one of the six filters; 3 KHz, 6 KHz, 12 KHz, 24 KHz, USB (2KHz) and LSB (2.8KHz). The 3 KHz filter is a specially modified filter for use in narrow band mode (see sec. 3.1.1 for narrow band operation). A set of FET quenching circuits have been added to quench this filter before the start of the next measurement. The quenching quickly removes any residual charge in the ceramic filter from the previous measurement.

These filters are selected automatically according to the bandwidth of the received signals or to the signal searching mode in operation. The output from these filters is then fed to AM and FM demodulators, the signal identification unit, the log IF and to the DSB carrier recovery loop for appropriate signal modulation identification.

2.3 IF Microprocessor Interface

This interface circuit enables the microprocessor to select and control the IF bandwidths, demodulation, gain and quenching. In addition there are two 8-bit analog-to-digital converters (ADC) which convert the log IF output and the IF envelope detector signals from the AM/AGC detector to digital data for input to the microprocessor.

2.4 Receiver Tuning Control

The receiver tuning control is executed either by the external microprocessor (Motorola 6800 EXORcisor) or by internal microprocessor (see digital tuner) and key pad. During automatic mode complete control of the receiver is provided by the Motorola EXORcisor system. Automatic mode and manual mode operations are fully explained in sections 3.1, 3.1.1 and 8.1.

2.4.1 Digital Tuner

Operation of the digital tuner is based around a WINTEK control module. It is a single card microprocessor system incorporating one MC 6800 microprocessor unit with associated two-phase clock, 512 bytes of RAM in the form of four MC 6810-1 128 byte RAMS and provision for an addition of 1K bytes of ROM in the form of one 2708 EPROM. The board also contains an MC 6850 asynchronous communications interface adapter (ACIA) and two MC 6820 peripheral interface adapters (PIA) which provide a 32 bit parallel interface with the receiver.

Frequency control is provided by a keypad on the front of the tuner unit. The keypad consists of 16 push buttons which are encoded by three MC 14503 tri-state CMOS buffers. The buffers are scanned by a National 74C922 key encoder. The encoder generates a four bit word corresponding to key pressed and transmits to the microprocessor. The microprocessor determines which key has been pressed and send commands to the receiver to output the correct frequency to both the front panel and to the synthesizer.

The band select and the synthesizer control signals are multiplexed using 74S157 multiplexer. This allows the receiver control to be easily switched from the manual tuner to the EXORcisor signal identification unit.

The software for the digital tuner control resides in an intel 2708 (1K x 8) EPROM. The software responds to interupts produced by the keypad entry. After each entry is made the band is selected according to Table 1 and the synthesizer frequency is calculated according to Table 2.

TABLE 2

BAND SELECTION CRITERIA

ENTERED FREQUENCY f_0 MHz	BAND SELECTION	SYNTHESIZER FREQUENCY f_c
1-30	A	$f_c = (122 + f_0)/2$
30-90	B	$f_c = (122 + f_0)/2$
90-195	C	$f_c = (70 + f_0)/2$
195-300	D	$f_c = (122 + f_0)/4$

3.0 FREQUENCY SCANNING METHODS

The receiver can perform two types of frequency scanning, narrow band scanning and broadband scanning. The basic procedure is identical, however, the receiver setup and measurement routines are different.

The scanning routine consists of an initialization routine and the scanning loop. The initialization, which is executed once, sets up the scanning mode display, inputs the centre frequency and other scanning parameters, sets up the receiver and starts scanning. Actual displaying of scan time, measurement results, and signal identification all occur within the scanning loop. At the end of each loop a check is made to see if the scanning process should be stopped or if the programs should return to manual mode.

3.1 Broad Band Scan (BBS)

In BBS an IF bandwidth of 30 KHz and a tuning step size of 30 KHz is used. This measurement routine waits 1.1 m.s at each step then reads the input signal level from ADC-1. This first reading is taken at maximum gain setting. After the reading, the routine checks the signal level. If the signal level is between the saturation region and the noise region then the dBm value of the signal is calculated. If the signal is in saturation region the gain is set to minimum and another reading is taken. If it is still in saturation region the dBm value is calculated and the overrange flag is set. If the signal is in the noise region the dBm value is calculated and the underrange flag is set.

At present only 5 discrete frequency bands are available for BBS. The available bands are 15 MHz, 30 MHz, 75 MHz, 150 MHz and 300 Mhz.

3.1.1 Narrow Band Scan (NBS)

This routine performs exactly the same function as the broad band measurement routine, except there is no 1.1 ms wait at each step. Instead a quench signal is applied for 6 ms prior to a 3 ms wait before the signal measurement is made.

Only frequency slots exibiting activity during the BBS and in the band selected by the operator may be scanned by this procedure. In this scan, an IF bandwidth of 3 KHz is used so that individual signals can be resolved. At present only 6 discrete frequency bands may be selected for NBS. The available frequency steps are 1.5 MHz, 3 MHz, 7.5 MHz, 15 MHz, 30 MHz and 75 MHz.

4.0 SIGNAL IDENTIFICATION PROCESS

The signal identification process is based on a combination of Amplitude Probability Distribution (APD) and Phase Lock Loop (PLL) methods. The APD method examines the IF envelope of the signal while the PLL method investigates the locking and modulation properties of the signal. The results of these two methods are combined and compared to an experimentally determined look-up logic table and if a match occurs for any type of signals listed in the look-up table then the receiver will claim that signal is identified. Otherwise the signal will remain unidentified.

4.1 APD Measurement Method

The method of measuring the APD data is by sampling the demodulated IF envelope. Fig. 2 shows the block diagram of the APD measurement method. After the IF signal is demodulated by the envelope detector, the signal envelope is fed into an analog to digital convertor (ADC). The digital data from the ADC is fed into the microprocessor via a PIA.

In present scheme three measurements are made. They are: mean, variance and P(x). P(x) stands for probability of having the value x, where x can be any number from zero to 255. After the IF envelope is sampled, the value x is gathered from the ADC. There are a total of 256 counters to keep track of all possible outcome of x. At the end of sampling, all the 256 counters are divided by the number of samples. The result is P(x).

The microprocessor reads a minimum of 256 (N = 1) samples (see Sec. 6.0). However, this number can be increased up to 8,388,608 (N = 15) by putting commands to the microprocessor. At the end of the sampling, the mean and the variance are computed.

From the results computed from 8192 (N = 5) samples the following general observation in Table 3 can be made.

TABLE 3

SUMMARY OF SIGNAL COMPARISONS

μ	σ^2	P(o)
AM < FM, CW, PSK	AM > FM, CW, PSK	AM, SSB, DSB ≃ 0
AM > SSB, DSB	AM < SSB, DSB	FM, CW, PSK = 0

The expected P(o) of AM is zero. However, if the AM signal is over modulated or if it is noisy P(o) of AM becomes slightly non-zero.

The results recorded above were for the IF bandwidth of 24 KHz. Repeated trials shows consistent results. However, the results do show some variations when the IF bandwidth changed from 24 KHz to 6 KHz.

For the 6 KHz, IF bandwidth and for same number of samples, the major differences are in FM and PSK signals. The variance of both FM and PSK changed substantially from small value to large value. Besides P(o) value of FM is no longer zero. However, AM, DSB, SSB and CW signals remain unaffected by the change of IF bandwidth.

4.2 PLL Method

In the second part of the signal identification process, three different phase lock loop circuits viz; AM loop, FM loop and DSB loop, provide four outputs each. The four outputs are: lock indication, modulation indication, frequency offset and demodulated signal output. The lock indicator and modulation indication outputs are used for PLL measurement, as shown in Fig. 3. The frequency offset output is used for measuring the signal frequency. The demodulated signal is not used at present time, but it could be used for measuring modulation index.

A brief description of all three PLL will be given now.

4.2.1 The AM Loop

As shown in Fig. 4, the IF input at 455 KHz is down converted, low-pass filtered and amplitude limited to a loop input frequency of 45 KHz. This limiting process removes most of the amplitude modulation before the signal which is now a square wave, is applied to the phase detector. The phase detector output is fed to the loop integrator via a low pass filter. The integrator output is applied to VCO whose centre frequency and range is 45 KHz ± 20 KHz and the output of VCO, which is 90° out of phase when locked, is fed back to the phase detector to complete the loop.

The output from VCO is further delayed 90° and is mixed with the input signal to form the coherent detection. The coherent detector output is again low pass filtered before this signal is applied to 'Lock Detection' and 'Modulation Detection' circuits.

The 'frequency offset' voltage which is used to calculate the signal frequency may be picked up from the loop integrator output. More on frequency offset is explained in section 7.0.

4.2.2 The FM Loop

Referring to Fig. 5, the IF input signal at 455 KHz is limited to remove any amplitude modulation. The limiter output is applied to a phase detector via a monostable multivibrator which produces narrow pulses of width approximately 200 ns. The VCO output is treated similarly and these output narrow pulses are used to set and reset a flip-flop which forms a phase detector. When the loop is locked these set and reset pulses are 180° out of phase. The phase detector output is filtered and passed to the loop integrator. The integrator output is applied to VCO whose centre frequency and range are 455 KHz ± 30 KHz. The output of the VCO is also connected to an auxiliary phase detector whose other input is the limited input signal. The output from this auxiliary phase detector is used to generate the 'Lock Detected' output when the loop is locked. The 'Modulation Detected' indication is derived from the VCO tuning voltage. This output is de-emphasized and filtered to select only voice frequency components in the range 300 to 3000 Hz. This filter output is detected and sensed by a comparator to give the 'Modulation Detected' output. A d.c. signal proportional to the signal off-set frequency is also available at the low pass filter output.

4.2.3 The DSB Loop

As shown in Fig. 4 the input for this loop is taken from the output of the low pass filter in the AM loop. This 45 KHz input is doubled, as shown in Fig. 6, filtered, amplitude limited and applied to a monostable multivibrator which supplies a square wave to the phase detector. The other output to the phase detector is from the VCO whose centre frequency and range are 90 KHz ± 40 KHz. The phase detector output is filtered, integrated and applied to the VCO to complete the loop connection.

Since the loop locks at 90° phase offset, another 90° phase shifter is used before this signal and the VCO signals are applied to the carrier detect circuit. Output from this circuit is filtered and sensed to give the 'Carrier Detected' output.

To demodulate the DSB signals, the carrier must be recovered by dividing the VCO frequency by 2 and is applied to the product detector which is a four quadrant multiplier whose other input is the 45 KHz signal to the DSB loop itself. The demodulated signal is passed to a 300 - 3000 Hz high-low pass filters which serves to select only the voice frequency components. The demodulated and filtered signal is detected and sensed to give the 'Modulation Detected' output.

The expected outputs (Lock indication and modulation indication) from the phase lock loops for AM, FM, PSK, CW, DSB and SSB signals are indicated in Table 4.

TABLE 4

EXPECTED PLL RESULTS

SIGNAL	AM-M	AM-L	FM-M	FM-L	DSB-M	DSB-L
AM	1	1	0	1	1	1
FM	x	0	1	1	x	0
PSK	1	0	1	1	1	1
CW	0	1	0	1	0	1
DSB	x	0	1	0	1	1
SSB	x	0	x	1	x	0

"1" indicates Lock condition

"0" indicates no-lock conditions

"x" indicates DON'T CARE

From Table 4 it can be observed that the AM loop and the DSB loop are expected to detect the modulation of AM signals and all these loops are expected to indicate the lock condition. On the other hand, the FM loop is expected to have no indication of detecting the modulation of the AM. Thus different lock and modulation indications can identify the six different signal types.

It should be pointed out that the unknown signals, being time-varying, can only be detected for a certain percentage of time. Therefore, a statistical average over a period of time becomes necessary in order to determine the locking and modulating properties of the signals.

In order to have good statistical significance, a large number of samples is required. In PLL measurements too, the microprocessor reads a minimum of 256 samples. As before, the number of samples can be increased to 8,388,608 (N = 15) by putting commands to the microprocessor.

5.0 SIGNAL IDENTIFICATION PROCEDURES

From the result of APD and PLL measurements it was observed that the different types of signal possess different combination of APD and PLL values. Although all the results can be used for signal identification only eight results are utilized. They are: Variance, P(o), AM-M, AM-L, FM-M, FM-L, DSB-M and DSB-L.

Table 5 shows a set of eight reference values which is used for signal identification. These reference values set the boundary so that the actual signal identification results can be compared to and a logical decision can be made.

TABLE 5

REFERENCE VALUES

AM-M	AM-L	FM-M	FM-L	DSB-M	DSB-L	σ^2	P(o)
31%	81%	63%	50%	25%	81%	256	0.0039

Table 6 shows a reference logic table. This reference logic table along with the reference values in Table 5 is used to identify the unknown signal.

TABLE 6

REFERENCE LOGIC TABLE

SIGNAL	AM-M	AM-L	FM-M	FM-L	DSB-M	DSB-L	σ^2	P(o)
AM	1	1	0	1	1	1	1	0
FM	x	0	1	1	x	0	0	0
PSK	1	0	1	1	1	1	0	0
CW	0	1	0	1	0	1	0	0
DSB	x	0	1	0	1	1	1	1
SSB	x	0	x	1	x	0	1	1

In the signal identification process there are essentially two levels of comparisons. After the signal has been measured by the APD and PLL methods, the statistical results are first compared to the reference values in Table 5. The result will be a set of logical values consisting of "1", or "0" . This logical results are then compared to the reference logic table in Table 6. If a match occurrs the signal is claimed to be identified, otherwise the signal will remain unidentified.

6.0 THE SIGNIFICANCE OF N

In the previous sections it was mentioned that the number of samples can be increased by inputting commands to the microprocessor. It was also indicated that a minimum of 256 ($N = 1$) samples will be taken for signal identification procedure. However, the number of samples can be increased by increasing the value assigned to N, from 1 to 15. Thus $N = 1$ represents 2^8 or 256 samples, $N = 2$ represents $2^8 \times 2^2$ etc. Finally for $N = 15$ a total number of $2^8 \times 2^{15}$ or 8,388,608 samples will be collected.

It was observed by experiment that,

a) As the value of N is increased, the percentage of correct identification also increased.

b) For $N \geq 4$ the percentage of correct identification was more than 90% for any of the six types of signals.

c) CW and PSK signals were identified 100 percent of the time even when $N = 1$.

These results are summarized in Table 7.

TABLE 7

PERCENTAGE OF SIGNAL IDENTIFICATION FOR N = 4

	AM	FM	DSK	CW	DSB	SSB
N = 4	94%	93%	100%	100%	99%	100%

Thus the value of N may be considered to be the efficiency of the signal identification process. Though higher value of N yields higher percentage of signal identification, as the value of N increases the time taken for signal identification also increases. It was observed that for $N = 1$, the programs takes 0.6 seconds to complete one signal identification process. Thus the value of N should be a compromise between percentage identification and time taken for signal identification.

7.0 SIGNAL FREQUENCY MEASUREMENT

As mentioned in section 4.2 one of the four outputs of the PLL circuit provides frequency offset information as DC voltage. The DC voltage is proportional to the difference between the receiver centre frequency and the signal frequency since if the receiver centre frequency is known the signal frequency can be computed.

The offset frequencies of different types of signal are measured by the three PLL's. The AM loop measures the AM and CW signals. The FM loop measures the FM signal alone. The DSB loop measures the DSB and PSK signals. After the signal is identified the appropriate D.C. Voltage is digitized and read by the microprocessor as shown in Fig. 7.

Based on the types of signal identified, the computer calculates the offset frequency using one of the predetermined curves shown in Fig. 8. Adding the result to or subtracting it from the receiver centre frequency the signal centre frequency is obtained.

8.0 MICROPROCESSOR SYSTEM

The heart of the ESM receiver system is the Motorola 6800 EXORcisor with 48 K bytes of memory, EXORdisk II floppy disks and the Tektronix 4025 graphic display terminal. The microprocessor system

a) Controls the receiver functions
b) Perform automatic scanning and signal identification
c) Accepts operator commands from the keyboard
d) Outputs data to the graphics terminal
e) Saves and recalls 10 pages of information.

8.1 Software Description

The software that controls the ESM system has been coded in 6800 assembler and is intended to be loaded and run using the standard Motorola Disk Operating System (MDOS 2.21). The program occupies approximately 24K bytes of memory plus 12K for MDOS.

The software controls the receiver by selecting the centre frequency, frequency span, threshold level, etc. under operator command. The receiver may be operated in one of two modes; manual mode and automatic mode. In the manual mode the operator has direct control of the receiver and is able to select the frequency, IF bandwidth, gain, signal identification, etc. by keyboard commands. In the automatic mode, the operator specifies the type of scan, centre frequency, frequency span, threshold level and signal identification. The receiver is automatically stepped through the selected band displaying a spectrum analyser type of trace on the graphic terminal and performs signal identification as required. In addition the operator can stop between traces and store or recall a trace and then continue scanning. Most keyboard commands are available via function keys on the Tektronix terminal.

8.2 Graphic Terminal

The 8080 microprocessor-based Tektronix 4025 graphic terminal can display a full 34 lines of 80 characters each on its 12 inch diagonal display screen. The display screen can be divided into two different work areas or scrolls of memory. The lower part of the screen displays monitor scroll while the upper part displays work space scroll. Text typed on the keyboard can be directed to either scroll, as can text coming from the microprocessor (host computer). The workspace can hold text when it is being edited while the monitor provides a separate display area where messages to and from the microprocessor may be displayed without overwriting the text in the workspace.

With appropriate Graphic Memory Options, the operator can create a graphic area in the workspace. Graphs can be made of solid lines or variety of dashed lines.

Each cursor cell contains 112 dot positions. It is 8 dots wide and 14 dots high. Thus the graphic region includes 304,640 addressable points. To draw a line in the graphics region, the 8080 processor first determine through which graphics cells the lines will pass. It then instructs the Graphics Memory board which dots should be turned on in each cell's dot matrix.

The keyboard is arranged in an office typewriter configuration, making it familiar to new users. A 4K memory is standard and is expandable to 32K.

The following are some of the features of 4025

a) Buffered text and local editing
b) Visual enhancements
c) Definable keys
d) Split Screen
e) Scrolling
f) Self test
g) Remotely programmable
h) Detached Keyboard
i) Hard copy provision

8.3 Information Display

At present the information is displayed on the screen in two different formats. Eight lines of graphic area and 26 lines of monitor area make up the manual mode display. Parameters such as centre frequency, step size, IF bandwidth, demodulation, gain settings, preselector and attenuator status are displayed in boxed format. Fig. 9 shows the manual mode display.

These parameters may be changed by an operator to its appropriate predetermined values. Using the 'UP' or 'DOWN' function keys the centre frequency may be changed to the 'STEP SIZE' shown in the box. If the operator requires identification of a signal at the centre frequency shown a 'SIGID' command will prompt the receiver to perform a signal identification and the result will be printed in the monitor area. The format used for displaying the result is the 'FREQUENCY', 'SIGNAL STRENGTH', 'SIGNAL TYPE' and the 'TIME' at which the signal was identified. If the signal identification is unsuccessful three consecutive "*" will be printed.

Unlike the manual mode format 28 lines of graphic area and 6 lines of monitor area defines the automatic mode display. Parameters such as frequency span, centre frequency, bandwidth, preselector and attenuator status are displayed in the graphic area. A continuous clock time is displayed in the right hand side-top of the graphic area.

However, as shown in Fig. 10, the major part of the graphic area is utilized for the display of the frequency spectrum. The vertical axis displays the signal strength from -10 dBm to -110 dBm and the horizontal axis displays the frequency span selected by the operator.

The centre frequency selected is 150 MHz and a total frequency span selected is 300 MHz. The resolution BW of 30 KHz shown on the right side of the bottom scale shows that the BBS was selected. Other information such as time, whether the preselector and attenuator are included or not are shown above the display. The display format for the signal identification result is similar to manual mode display.

Figure 11 is an expanded portion of the Fig. 10. This figure shows the frequency span of 15 MHz centred at 100 MHz ie the frequency span displayed corresponds to the frequency span between 97.5 MHz and 107.5 MHz. Figure 12 shows the same frequency span but display obtained by NBS.

9.0 CONCLUSIONS

The ESM receiver was developed by a research-oriented development contract. One of the novel ideas which needs improvement is the signal identification procedure. The advantage of this procedure is that it is software oriented and therefore the software may be changed to enhance the signal identification procedure keeping the hardware intact. The addition of the digital tuner makes the manual mode operation much simpler and faster.

A second receiver, a ruggedized version of the present one, is under development of Miller Communications Systems and it is expected that efforts will be made to eliminate these problems.

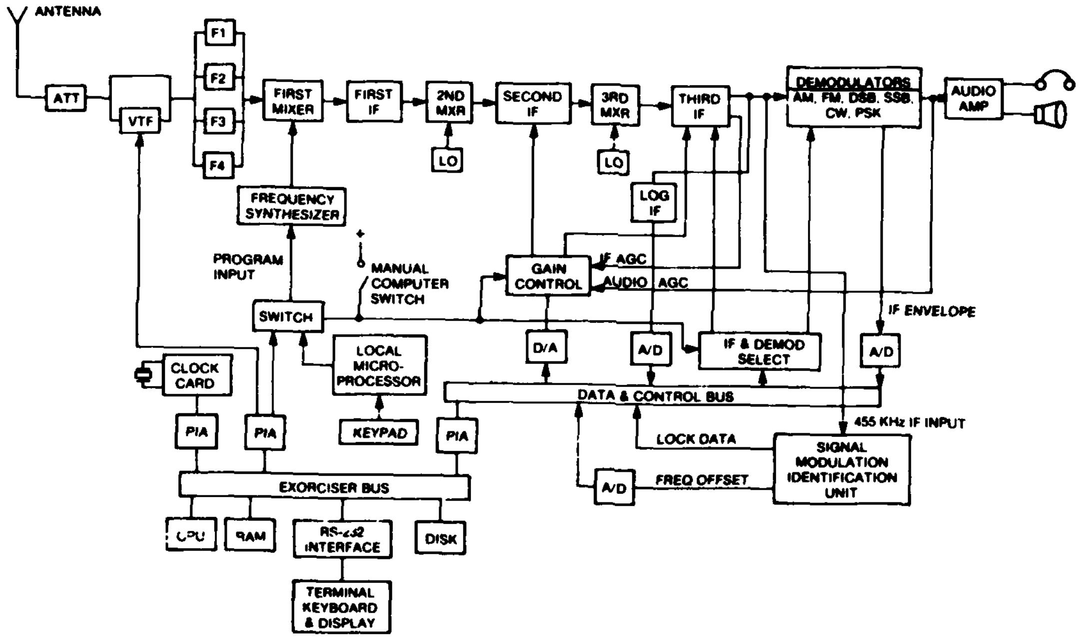


FIG. 1 - SYSTEM BLOCK DIAGRAM

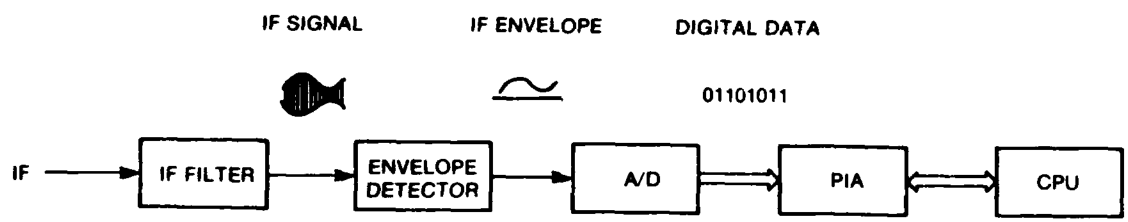


FIG. 2 - APD MEASUREMENT METHOD

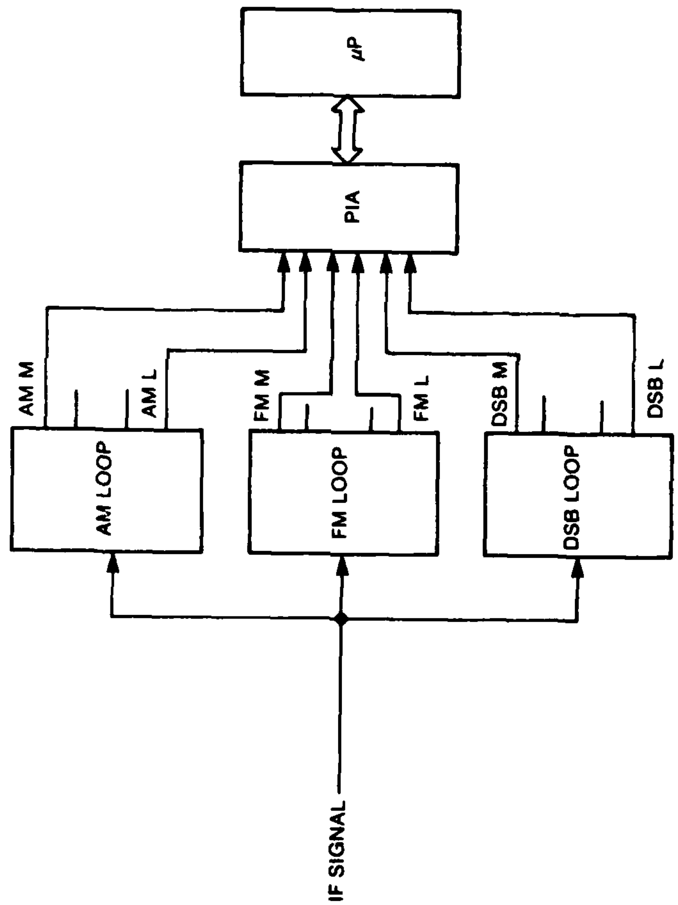


FIG. 3 - PHASE LOCK LOOP MEASUREMENT

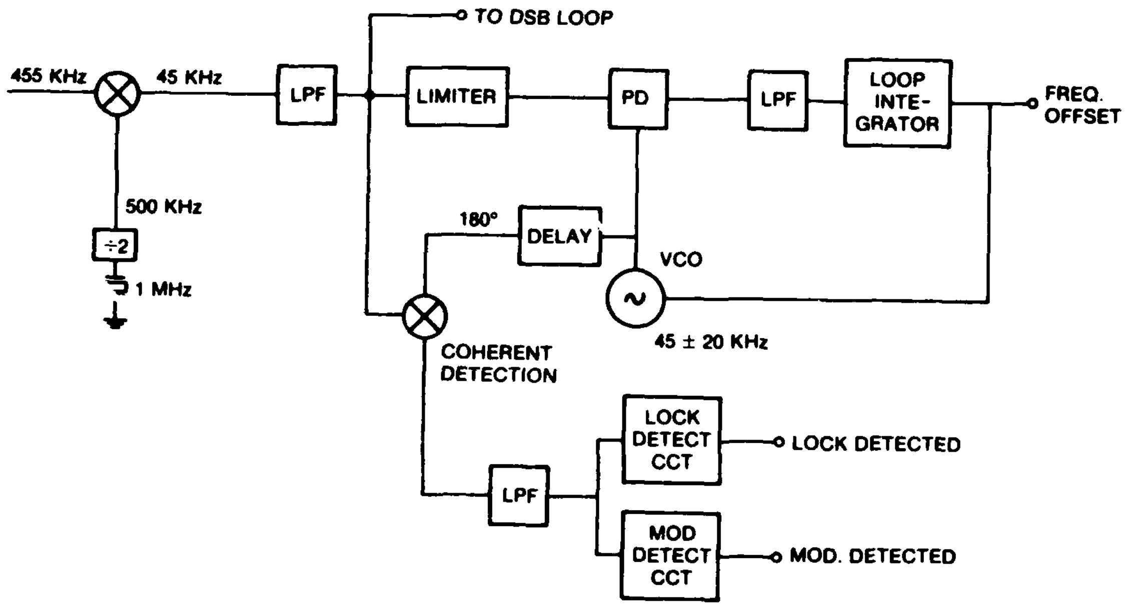

TO DSB LOOP
455 KHz
45 KHz
LPF
LIMITER
PD
LPF
LOOP INTE-GRATOR
FREQ. OFFSET
500 KHz
÷2
1 MHz
180°
DELAY
VCO
45 ± 20 KHz
COHERENT DETECTION
LPF
LOCK DETECT CCT
LOCK DETECTED
MOD DETECT CCT
MOD. DETECTED

FIG. 4 - AM LOOP

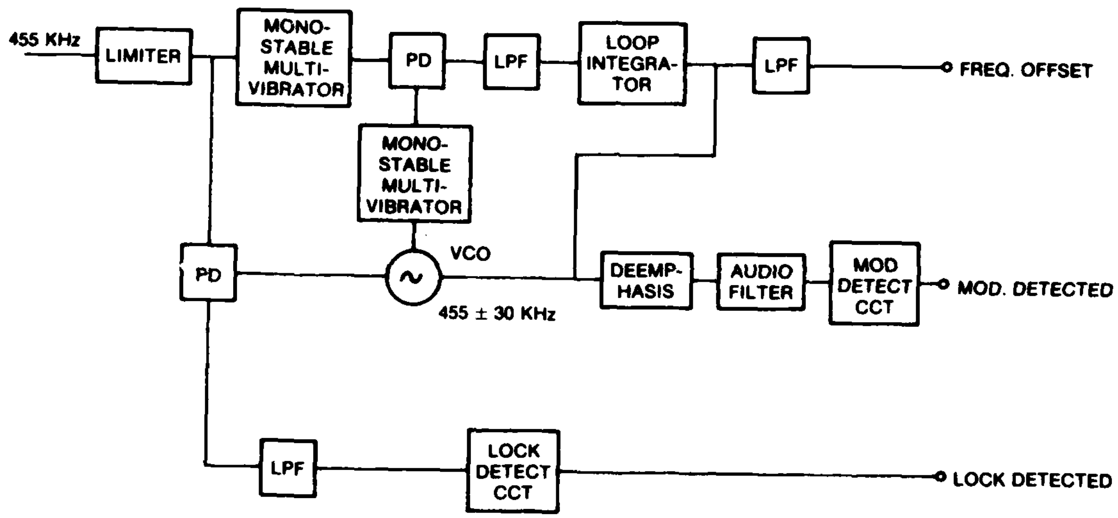

455 KHz
LIMITER
MONO-
STABLE
MULTI-
VIBRATOR
PD
LPF
LOOP
INTEGRA-
TOR
LPF
FREQ. OFFSET
MONO-
STABLE
MULTI-
VIBRATOR
VCO
PD
455 ± 30 KHz
DEEMP-
HASIS
AUDIO
FILTER
MOD
DETECT
CCT
MOD. DETECTED
LPF
LOCK
DETECT
CCT
LOCK DETECTED

FIG. 5 - FM LOOP

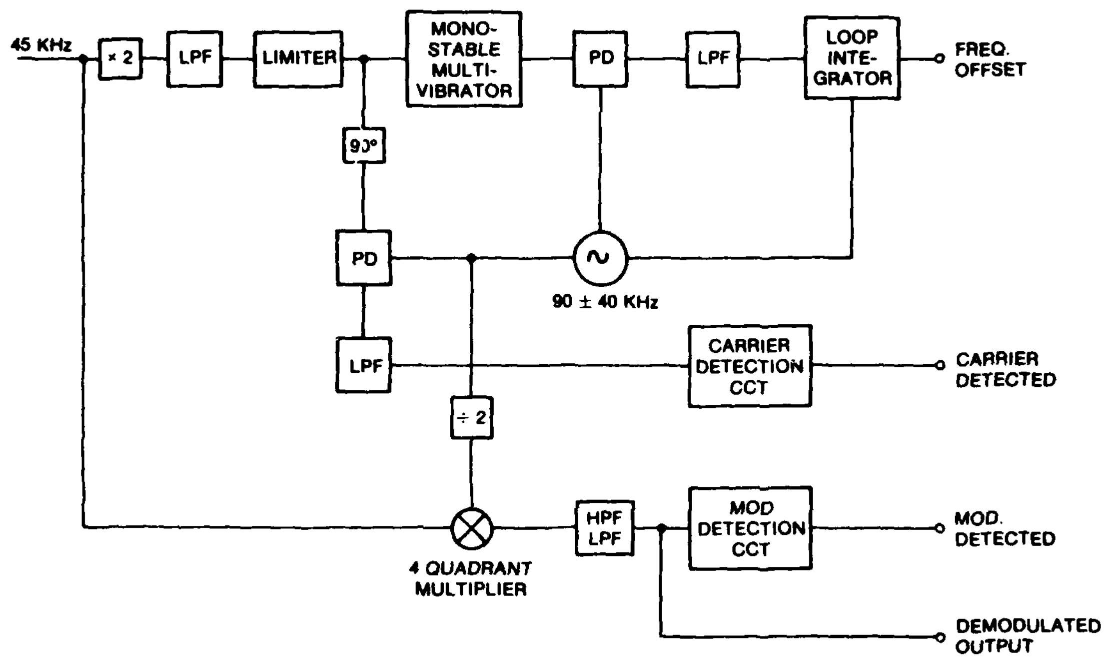


FIG. 6 - DSB LOOP

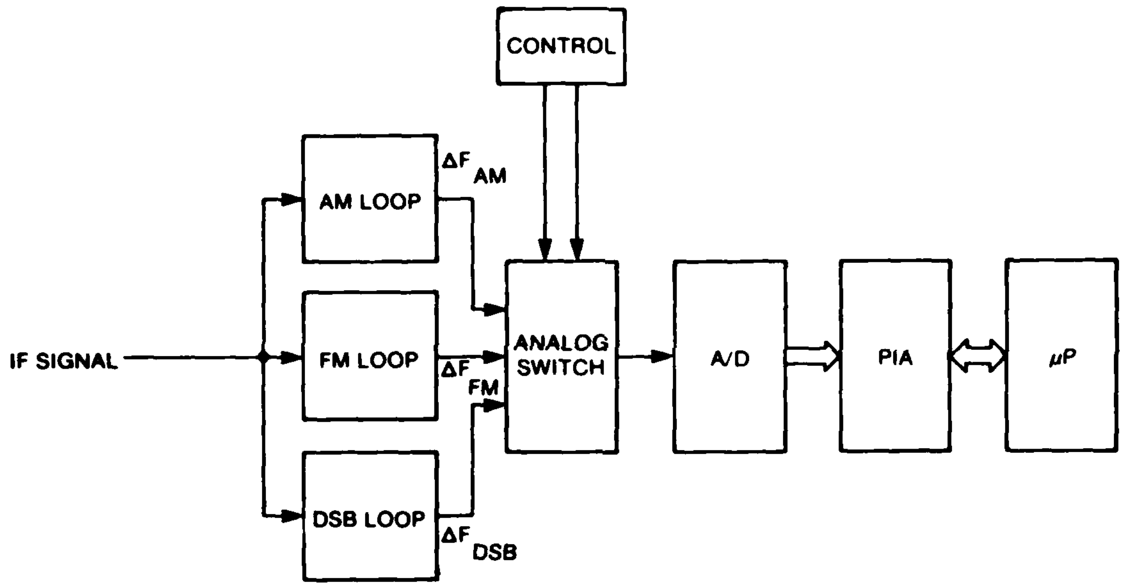


FIG. 7 - SIGNAL FREQUENCY MEASUREMENT

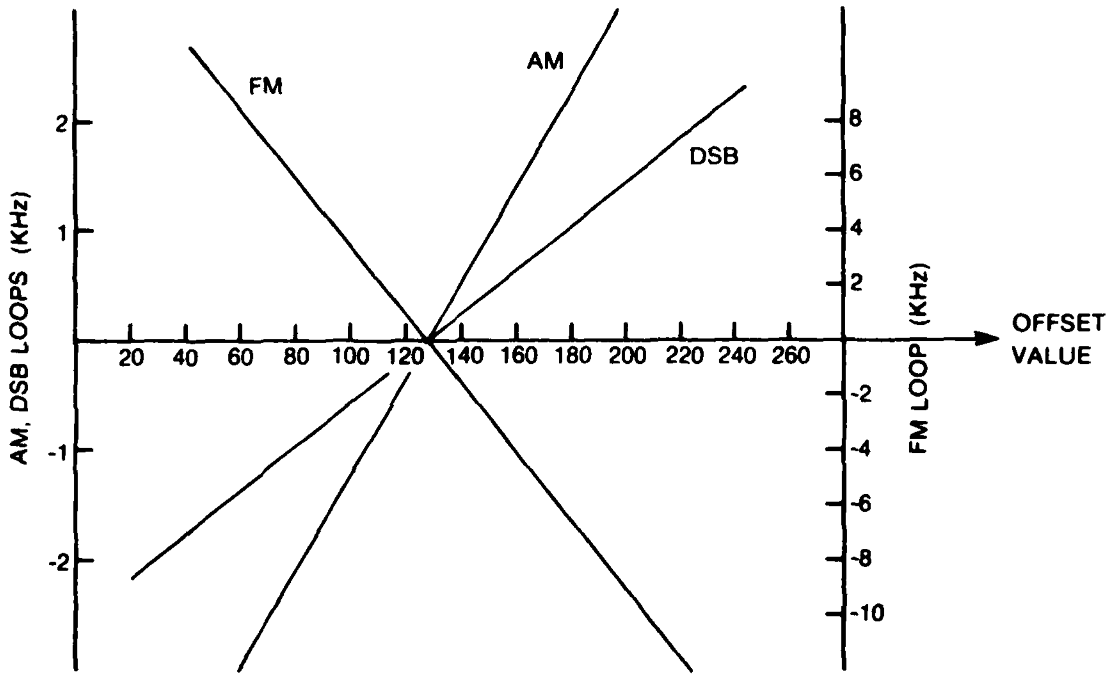


FIG. 8 - CHART FOR OFFSET VALUE

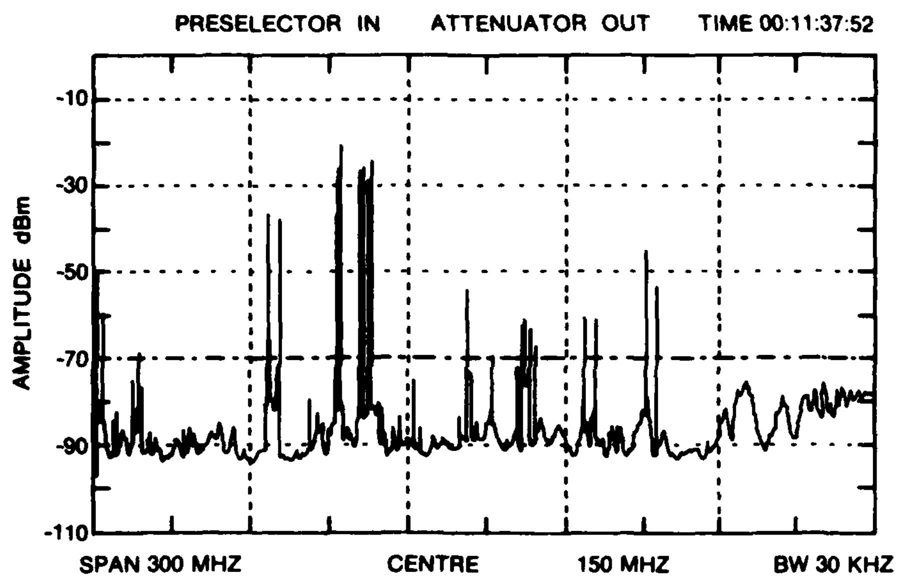
CENTRE FREQ. 77.5 MHZ		STEP SIZE 500 KHZ
IF BW 30 KHZ	DEMOD AM	GAIN AUTO
PRESELECTOR IN		ATTENUATOR OUT

DEMOD A
SIGID
75.4947 MHZ -105.6 DB FM 00:12:06:14

UP
SIGID
76 MHZ -105.9 DB *** 00:12:07:31

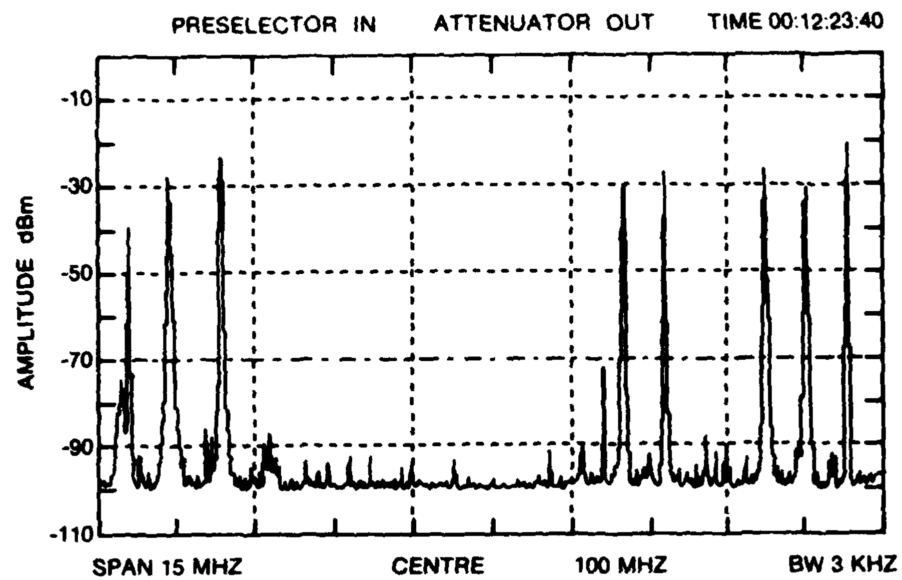
IF 24
SIGID
76 MHZ -105.6 DB *** 00:12:08:03

FIG. 9 - MANUAL MODE DISPLAY



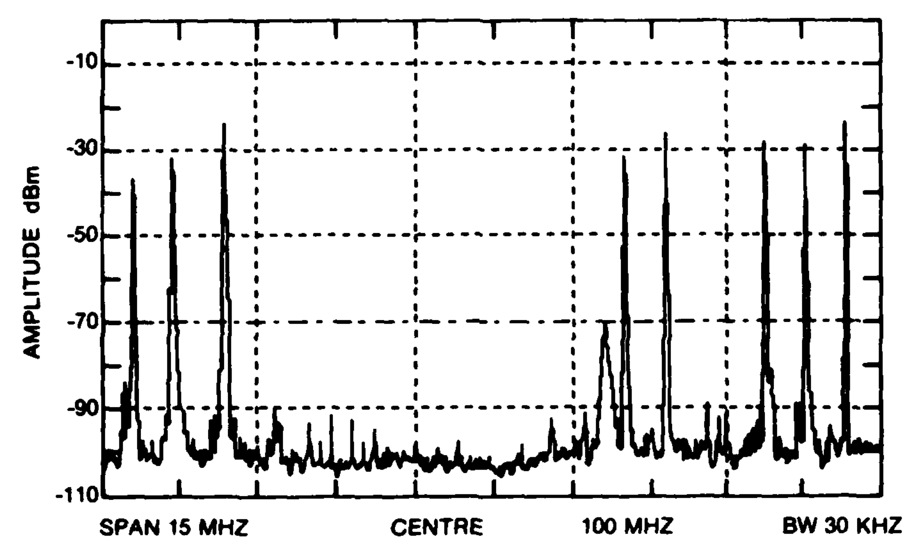
215.76 MHZ	-56.6 DB	***	00:11:37:29
215.97 MHZ	-56.6 DB	***	00:11:37:30
290.34 MHZ	-64.7 DB	***	00:11:37:49
290.3842 MHZ	-63.5 DB	FM	00:11:37:49
296.3561 MHZ	-63.7 DB	FM	00:11:37:51
296.37 MHZ	-62.3 DB	SSB	00:11:37:52

FIG. 10 - COMPLETE FREQUENCY SPECTRUM (AUTOMATIC MODE DISPLAY)



106.918 MHZ	-45.9 DB	SSB	00:12:23:37
106.921 MHZ	-46.6 DB	SSB	00:12:23:38
106.924 MHZ	-61.9 DB	SSB	00:12:23:38
106.927 MHZ	-21.1 DB	SSB	00:12:23:39
106.939 MHZ	-69.4 DB	SSB	00:12:23:39
106.9727 MHZ	-67.6 DB	FM	00:12:23:40

FIG. 11 - 15 MHz FREQUENCY, NBS, f_c = 100 MHz



106.12 MHZ	-42.2 DB	SSB	00:11:46:58
106.15 MHZ	-60.9 DB	SSB	00:11:46:59
106.84 MHZ	-65.0 DB	SSB	00:11:47:01
106.87 MHZ	-27.0 DB	SSB	00:11:47:02
106.9 MHZ	-24.0 DB	SSB	00:11:47:03
106.93 MHZ	-34.1 DB	SSB	00:11:47:03

FIG. 12 - 15 MHz FREQUENCY SPAN, BBS, f_c = 100 MHz

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATING ACTIVITY Defence Research Establishment Ottawa National Defence Headquarters, Ottawa, Ontario K1A 0Z4	2a. DOCUMENT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP
3. DOCUMENT TITLE HF/VHF SPECTRUM SURVEILLANCE ESM RECEIVER (U)	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) TECHNICAL NOTE	
5. AUTHOR(S) (Last name, first name, middle initial) LUIZ, R.	
6. DOCUMENT DATE September 1981	7a. TOTAL NO. OF PAGES 37 7b. NO. OF REFS None
8a. PROJECT OR GRANT NO. 31E10	9a. ORIGINATOR'S DOCUMENT NUMBER(S) DREO # 81-17
8b. CONTRACT NO.	9b. OTHER DOCUMENT NO.(S) (Any other numbers that may be assigned this document)
10. DISTRIBUTION STATEMENT UNLIMITED	
11. SUPPLEMENTARY NOTES	12. SPONSORING ACTIVITY

13. ABSTRACT

This report provides the design criteria, functions, capabilities and drawbacks of a HF/VHF spectrum surveillance ESM Receiver. It is designed to perform scanning of an operator-selected frequency band and perform signal identification upon detecting a signal. More emphasis is given, in this report, to the signal identification procedure which is one of the novel innovations incorporated into the receiver. The ESM Receiver is capable of identifying CW, AM, FM, SSB, DSB and PSK signals.

DSIS
72-508

UNCLASSIFIED

Security Classification

KEY WORDS

RECEIVERS

SPECTRUM SURVEILLANCE

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the organization issuing the document.

2a. DOCUMENT SECURITY CLASSIFICATION: Enter the overall security classification of the document including special warning terms whenever applicable.

2b. GROUP: Enter security reclassification group number. The three groups are defined in Appendix 'M' of the DRB Security Regulations.

3. DOCUMENT TITLE: Enter the complete document title in all capital letters. Titles in all cases should be unclassified. If a sufficiently descriptive title cannot be selected without classification, show title classification with the usual one-capital-letter abbreviation in parentheses immediately following the title.

4. DESCRIPTIVE NOTES: Enter the category of document, e.g. technical report, technical note or technical letter. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the document. Enter last name, first name, middle initial. If military, show rank. The name of the principal author is an absolute minimum requirement.

6. DOCUMENT DATE: Enter the date (month, year) of Establishment approval for publication of the document.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the document.

8a. PROJECT OR GRANT NUMBER: If appropriate, enter the applicable research and development project or grant number under which the document was written.

8b. CONTRACT NUMBER: If appropriate, enter the applicable number under which the document was written.

9a. ORIGINATOR'S DOCUMENT NUMBER(S): Enter the official document number by which the document will be identified and controlled by the originating activity. This number must be unique to this document.

9b. OTHER DOCUMENT NUMBER(S): If the document has been assigned any other document numbers (either by the originator or by the sponsor), also enter this number(s).

10. DISTRIBUTION STATEMENT: Enter any limitations on further dissemination of the document, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this document from their defence documentation center."

(2) "Announcement and dissemination of this document is not authorized without prior approval from originating activity."

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document, even though it may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall end with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (TS), (S), (C), (R), or (U).

The length of the abstract should be limited to 20 single-spaced standard typewritten lines; 7½ inches long.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a document and could be helpful in cataloging the document. Key words should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context.